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EXAMINER

BROCK II, PAUL E

ART UNIT

PAPER NUMBER

2815

DATE MAILED: 01/19/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/721,971

Applicant(s)

SUN ET AL.

Examiner

Paul E. Brock II

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-20 is/are pending in the application.
- 4a) Of the above claim(s) ____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) ____ is/are allowed.
- 6) ☒ Claim(s) 1-11, 14-18 and 20 is/are rejected.
- 7) ☒ Claim(s) 12, 13 and 19 is/are objected to.
- 8) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 24 November 2003 is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. ____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- ☒ Notice of References Cited (PTO-892)
- ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date 6-23-04 3-26-04.
- ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. ____.
- ☐ Notice of Informal Patent Application (PTO-152)
- ☐ Other: ____.

DETAILED ACTION

Drawings

1. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, “the series of tilted calcium ion implants” must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as “amended.” If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. The replacement sheet(s) should be labeled “Replacement Sheet” in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claims 6, 7 rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

4. Claim 6 recites the limitation "the series of tilted calcium ion implants" in the first and second lines of the claim. There is insufficient antecedent basis for this limitation in the claim. For purposes of this office action "the series of tilted calcium ion implants" will be considered --the calcium ion implantation--.

5. Claim 7 recites the limitation "the series of tilted calcium ion implantation steps" in the first and second lines of the claim. There is insufficient antecedent basis for this limitation in the claim. For purposes of this office action "the series of tilted calcium ion implantation steps are" will be considered --the calcium ion implantation is--.

Claim Rejections - 35 USC § 102

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

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(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

7. Claims 1, 2, 4, 7, 8, 16 – 18, and 20 are rejected under 35 U.S.C. 102(e) as being anticipated by Lopatin et al. (USPAT 6703307, Lopatin).

With regard to claim 1, Lopatin discloses in figures 6, figure 7, and column 5, lines 40 – 47 a method of forming a damascene interconnect barrier layer (630/755). Lopatin discloses in figures 6 and 7 forming a trench (705) in a dielectric layer (715). Lopatin discloses in figure 6, figure 7, and column 5, lines 3 – 19 implanting Ca ions into the sidewalls of the trench (it should be noted that 620 are considered the sidewalls). Lopatin discloses in figures 2, 3, 6, and 7 forming an inlaid metal conductor in the trench is inherent in the method of Lopatin because the entire method is devoted to improving the barrier/seed layers of a damascene process.

With regard to claim 2, Lopatin discloses in figure 7 and column 6, lines 40 – 50 wherein the Ca ion implantation is conducted using a series of tilted implants.

With regard to claim 4, Lopatin discloses in figure 5, column 9 – 11 wherein the calcium ion implantation generates a calcium concentration profile extending from the surface of the trench sidewall to a depth of 30 Angstroms (it should be noted that a depth of 30 Angstroms reads on the claimed range).

With regard to claim 7, Lopatin discloses in column 6, line 44 wherein the calcium ion implantation is conducted at about a 90 degree angle to the surface of the substrate.

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With regard to claim 8, Lopatin discloses in column 6, line 44 further comprising implanting a concentration of calcium ions into the bottom of the channel using a straight implant. It should be noted that an ion implantation that is conducted at about a 90 degree angle to the surface of the substrate is a straight implant.

With regard to claim 16, Lopatin discloses in figure 7 wherein the trench is formed in a dual damascene process.

With regard to claim 17, Lopatin discloses in figures 1, 2, 6, and 7 a semiconductor integrated circuit. Lopatin discloses in figures 1, 2, 6, and 7 a dielectric layer. Lopatin discloses in figures 1, 2, 6 and 7 an inlaid copper conductor formed in a channel in the dielectric layer. Lopatin discloses in figures 1, 2, 6 and 7 a first calcium implant region comprising a concentration of Ca atoms incorporated into the sidewalls of the channel using ion implantation.

With regard to claim 18, Lopatin discloses in figure 6, figure 7, and column 5, lines 3 – 19 wherein the concentration of Ca atoms is positioned at a depth of 30 Angstroms from the surface of the sidewall of the channel (it should be noted that a depth of 30 Angstroms reads on the claimed range).

With regard to claim 20, Lopatin discloses in figure 7 further comprising a concentration of calcium ions implanted into the bottom of the channel.

Claim Rejections - 35 USC § 103

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

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(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

9. Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lopatin as applied to claim 1 above, and further in view of one of ordinary skill in the art.

With regard to claim 5, Lopatin discloses in column 5, lines 3 – 19 wherein the calcium ion implantation generates a calcium layer thickness of 30 Angstroms. This would inherently mean that the peak calcium concentration of Lopatin within 30 Angstroms from the trench sidewall. It is well known in the art to optimize the thickness of a layer (see MPEP 2144.05 II). It would have been obvious to one of ordinary skill to have a calcium layer thickness wherein the peak calcium concentration would be 50 angstroms from the surface of the trench in order to optimize the layer performance.

10. Claims 3 and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lopatin as applied to claim 1 above, and further in view of Hook et al. (USPAT 6083794, Hook).

With regard to claim 3, Lopatin discloses in column 6, lines 40 – 50 wherein the tilt angle ranges from 0 to 30 degrees (i.e. implantation angle of 60 – 90 degrees). Lopatin does not disclose twist angle increments. Hook discloses in figure 1 a four-way implant rotation. It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the four way implant rotation of Hook for the calcium ion implant in the method of Lopatin in order to implant uniformly into four square sides of semiconductor structures. It would have been further obvious in the method of Lopatin

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and Hook wherein the twist angle increments of 90 degree per rotation to accomplish the four-way rotation (i.e. $360/90 = 4$).

With regard to claim 6, it is not clear if Lopatin teaches a four-way implant rotation for the calcium implant. Hook discloses in figure 1 a four-way implant rotation. It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the four way implant rotation of Hook for the calcium ion implant in the method of Lopatin in order to implant uniformly into four square sides of semiconductor structures. It would have been further obvious in the method of Lopatin and Hook wherein the calcium ion implant is conducted such that about 25% of calcium is implanted in the trench sidewalls for a given twist angle.

11. Claims 9 – 11, 14, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lopatin as applied to claim 1 above, and further in view of Besser et al. (USPAT 6703308, Besser).

With regard to claim 9, Lopatin discloses in figure 7 the first calcium ion implanted layer. Lopatin does not disclose a second calcium ion implanted layer. Besser teaches in figures 5 and 6 further comprising forming a second calcium ion implanted layer (480) above the top surface of an inlaid metal conductor wherein the second calcium ion implantation is conducted with Ca ions. It would have been obvious to one of ordinary skill in the art at the time of the present invention to use the second calcium ion implant of Besser in the method of Lopatin in order to reduce interface diffusion as stated by Besser in column 4, lines 29 – 31. Besser teaches in column 4, line 10 using 5 keV energy for the second implant. Lopatin and Besser are silent to an energy of 10 keV

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for the second implant. It would have been obvious to one of ordinary skill in the art to use 10 keV energy for the second ion implantation in order to optimize the implantation (See MPEP2144.05 II).

With regard to claim 10, Besser discloses in figure 5 column 4, lines 8 – 9 wherein the second calcium ion implantation is conducted with Ca ions using a 0 degree tilt (i.e. no implant angle). Besser teaches in column 4, line 10 using 5 keV energy for the second implant. Lopatin and Besser are silent to an energy of 10 keV for the second implant. It would have been obvious to one of ordinary skill in the art to use 10 keV energy for the second ion implantation in order to optimize the implantation (See MPEP2144.05 II).

With regard to claim 11, Besser discloses in figure 5 and column 4, lines 8 – 9 wherein the second calcium ion implantation is conducted with a $5 \times 10^{14} \text{ cm}^{-2}$ ion dose (it should be noted that Besser's disclosed range reads on the claimed range).

With regard to claim 14, Lopatin discloses in figure 1 wherein the inlaid conductor is copper. Besser disclose sin figures 5 – 6 and column 4, lines 1 – 30 the second calcium ion implantation is formed directly on the top surface of the inlaid conductor.

With regard to claim 15, Lopatin discloses in figure 7 wherein the trench is formed in a dual damascene process. Lopatin does not disclose a single damascene process. Besser teaches in figures 4 – 6 wherein the trench is formed in a single damascene process. It is well know in the art to use a single damascene or a dual damascene process, therefore, it would have been obvious to one of ordinary skill in the art at the time of the present invention to use the single damascene of Besser in the

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method of Lopatin in order to apply the method of Lopatin to a greater range of products and therefore decrease processing costs for developing new processes.

Allowable Subject Matter

12. Claims 12, 13, and 19 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

13. The following is a statement of reasons for the indication of allowable subject matter: The prior art of record does not disclose or suggest at least the claim limitations of: "wherein said second calcium ion implantation is formed in a low-k layer disposed directly on the top surface of the inlaid conductor," in claims 12 and 13; and "a second calcium ion implanted region formed in a low-k layer disposed directly on the top surface of the inlaid conductor," in claim 19.

Conclusion

14. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Besser et al. '085 and Maruyama both disclose calcium implantation.

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Any inquiry concerning this communication or earlier communications from the examiner should be directed to Paul E. Brock II whose telephone number is (571) 272-1723. The examiner can normally be reached on 8:30 AM - 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tom Thomas can be reached on (571) 272-1664. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Paul E Brock II

A handwritten signature in black ink, appearing to read 'Paul E. Brock II', written in a cursive style.